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PROJECT MERCURY (U)

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STATUS REPORT NO. 12

FOR

GP-4

PERIOD ENDING OCTOBER 31, 1961

NASA.

By Manned Spacecraft Center, Langley Station, Va
[1961]

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INTRODUCTION

This report is the twelfth in a series of reports on the status of the NASA manned-satellite project, PROJECT MERCURY. Earlier Status Reports covered the progress made through July 31, 1961.

The hardware construction and qualification phase of the project is still proceeding. The orbital flight phase is now underway.

Since the last reporting date, McDonnell Aircraft Corporation has delivered two more production spacecraft, making a grand total of 15. The breakdown of the delivered craft is as follows: 10 have been flown, two of these having been flown twice; three are undergoing flight-test preparations; one is being utilized as a Reaction Control System test bed; and one is being used for an environmental test program at St. Louis, Missouri.

One flight has been conducted since July 31, 1961. MERCURY-Atlas 4 was successfully flown on September 13, 1961. This was the first MERCURY production spacecraft to attain an earth orbit, reaching an apogee of 123 nautical miles and a perigee of 86 nautical miles. The capsule contained special vibration and noise instrumentation and a mechanical crewman simulator in addition to the standard onboard systems. All test objectives were accomplished and the capsule was recovered approximately $1\frac{1}{2}$ hours after landing.

The MERCURY-Redstone suborbital flight test program has been completed.

The MERCURY-Atlas flight-test program is continuing although there are still problems that have not been solved on the Atlas launch vehicle.

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MA-4 provided the first flight-test exercise of the Range Network system. The results are presented in the "Communications" section of this report.

The Astronaut training program is continuing with emphasis on the Atlas orbital missions.

MANUFACTURING AND DELIVERY

The manufacturing and delivery efforts (including disposition of spacecraft after flight test) of PROJECT MERCURY are discussed in the following paragraphs:

Capsule no. 1 (Beach Abort) was assembled to a McDonnell-constructed sled assembly for the capsule adapter separation tests at the Naval Ordnance Test Site (NOTS), China Lake, California. This assembly was shipped August 23, 1961.

Tests were run on September 5, 9, and 14, 1961, and the assembly was returned to McDonnell on September 16, 1961. The capsule is now in storage at McDonnell.

Capsule no. 5 (MR-2) continues to be used as a test vehicle by the Manned Spacecraft Center (MSC) at Langley Air Force Base, Virginia for the following tests:

1. The seaworthiness test was conducted to evaluate the life expectancy of the production impact cushion components. This test was completed on August 3, 1961.

2. The evaluation of an inflatable flotation collar attached by ground personnel for sustaining capsule buoyancy during the recovery period was completed on September 28, 1961.

3. Egress and recovery tests with astronaut participation and the use of naval surface vessels as recovery vehicles were completed October 27, 1961. Capsule no. 5 is presently located at the MSC.

Capsule no. 6 (MA-2) continues to be used for testing communication and power requirements by McDonnell. The following tests have been completed: low voltage, 150 v-amp inverter and battery diode bypass for practical voltage gain. High-frequency radio noise tests were suspended until new commutators are received.

Capsule no. 7 (MR-3) preparation and final assembly for display at the Smithsonian Institution was completed on September 5, 1961. The

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capsule was shipped to the Smithsonian Institution where it is now on permanent display.

Capsule no. 8A (MA-4) was successfully launched on September 13, 1961 and recovered the same day. The capsule was returned to Cape Canaveral, Florida for postflight study. These studies were completed on October 3, 1961 and the capsule was shipped on October 4, 1961 via the MSC and General Dynamics/Astronautics (GD/A), San Diego, California and arrived at McDonnell on October 16, 1961. The capsule will undergo further postflight studies, upon completion of which the capsule will be prepared for storage by general cleanup and treating for saline corrosion.

Capsule no. 9 (MA-5) is in a period of launch preparation at Cape Canaveral. Launch is scheduled for November 29, 1961.

Capsule no. 10 (Project Orbit) tests during the period from August 1, 1961 through October 31, 1961 have been centered around evaluation of current fixes for cabin and equipment heating in multiorbit modes.

Capsule no. 11 (MR-4) was launched on July 21, 1961 and the mission was accomplished. The capsule was lost on recovery.

Capsule no. 12 (MA-6 alternate) is being considered for conversion at Cape Canaveral, Florida from orbital-primate to an 18-orbit manned capability pending a successful flight of capsule no. 9 (MA-5). Due to the aforementioned consideration, the flight number designations have been changed on capsules nos. 13, 16, 18 and 19.

Capsule no. 13 (MA-6, previously MA-7) was delayed 13 days from the date published in figure 1 of Status Report No. 11 in order to incorporate Cape Canaveral generated work and correct cabin leaks. The final simulated mission was completed on August 22, 1961. The capsule was shipped to Cape Canaveral on August 27, 1961.

Capsule no. 14A (LJ-5B) has been repaired of the damages incurred during the explosive hatch tests. On August 15, 1961 it was used for a hatch leak test which investigated the cabin leak rate. This test was performed by removing one bolt at a time until cabin pressure could not be maintained. Upon completion of this test, the capsule was placed in storage. On October 26, 1961, the capsule was shipped to Houston, Texas for display and is due back in storage at McDonnell in mid-November.

Capsule no. 15 (unassigned, previously MR-5) was delayed 1 week from the date published in figure 1 of Status Report No. 11, due to Cape Canaveral generated work. The capsule was shipped to Cape Canaveral on August 13, 1961. Due to mission cancellation, the capsule was used for tests on the Reaction Control System (RCS) and Environmental Control System (ECS) under simulated altitude. Capsule no. 15 is presently being used to verify the effectiveness of peroxide cleaning and drying procedures applied to capsule no. 9. This capsule is also being considered for return to McDonnell for conversion to an 18-orbit manned capsule.

Capsule no. 16 (MA-8, previously unassigned) was delayed 2 months from the date published in figure 1 of Status Report No. 11. The reasons for this delay are the manufacturing modifications required by mission change and the decision to conduct a full Capsule Systems Test (CST). The present estimated delivery date of capsule no. 16 is the week of December 4, 1961.

Capsule no. 17 (unassigned) delivery is now estimated for the week of January 22, 1962, approximately $2\frac{1}{2}$ months later than the date published in figure 1 of Status Report No. 11. This capsule is being considered for conversion to an 18-orbit manned capsule.

Capsule no. 18 (MA-7, previously MA-8) has completed the rework period. The decision to rerun a full CST due to major modifications made during this rework period has delayed this capsule approximately 7 weeks from the date published in figure 1 of Status Report No. 11. The capsule is now in a rework period prior to final simulated missions test scheduled for completion November 9, 1961. The present estimated delivery date of capsule no. 18 is the week of November 13, 1961.

Capsule no. 19 (unassigned, previously MA-9) is still in the manufacturing period prior to CST. CST, which was scheduled to start August 13, 1961 as noted in Status Report No. 11, was delayed by the shortage of instrument packages and topic cards. It was decided to reschedule the incorporation of engineering changes during this period instead of during the rework period between preliminary simulated missions and final simulated missions. Due to the above shortages and the rescheduling of engineering changes, CST is scheduled to start November 6, 1961. The present estimated delivery date for capsule no. 19 is the week of January 22, 1962.

Capsule no. 20 (unassigned) continues to be in the manufacturing period prior to CST, which is estimated to start November 10, 1961. The present estimated delivery date of capsule no. 20 is the week of January 8, 1962. This capsule is being considered for conversion to an 18-orbit manned capsule.

MERCURY-Scout (MS-1) payload was removed from the booster and sent to Aeronutronics Division, Ford Motor Company, Newport Beach, California on August 5, 1961 for higher vibrational level tests and returned to Cape Canaveral on September 20, 1961. The fourth-stage assembly was sent to Allegany Ballistics Laboratory for modification to igniter and pull-away connectors. It was returned to Cape Canaveral on October 14, 1961.

Figure 1, PROJECT MERCURY Master Planning Schedule, shows capsule delivery, prelaunch preparation time, and launch dates and sites.

MAJOR SYSTEMS

Capsule

The present status and other plans for the various major systems of PROJECT MERCURY are given in the following sections:

Configuration and weight.- There have been no significant configuration changes since Status Report No. 11; however, equipment and detail changes have resulted in further weight increases. The effective launch weight is continuing to increase at approximately 20 pounds per month. The current effective launch weight is 3,329 pounds, the orbit weight is 2,924 pounds, and reentry weight is 2,639 pounds.

Structures and heat shield.- Ablation shield S/N-16, which included the center plug design change, was sectioned to provide simulated reentry temperature and bending specimens. Six specimens were specially laid up, three with Epoxylite 5403 and three with SC1008 adhesive bond, to evaluate bond joint strength. Three center plug specimens included one shear dowel per specimen and two center plug specimens had no dowels. All specimens were heated to a bond joint temperature of 500° F and loaded in bending to failure. Bending failures all occurred in an acceptable stress range above the calculated impact stress level of 16,000 psi. The Epoxylite 5403 bonded specimens failed at slightly higher stresses than the SC1008 bond. During the sectioning of the ablation shield, voids were revealed in the bond joint between the center plug and the parallel laminate. X-ray of all completed shields revealed varying lack of bond up to 50 percent. This defect initiated a change of fabrication procedure on shields yet to be completed and rework of shield S/N-17.

Static Article No. 2 was assembled with impact bag equipment and tested to evaluate shield release while at elevated temperatures. The first run indicated galling of the release mechanism due to chrome-plating edge buildup. Rework and replacement of the test hardware with production parts covered by inspection resulted in acceptable release pressures of 1,440 psi to 1,760 psi after being subjected to an ultimate temperature of about 250° F.

The recovery compartment was subjected to a simulated 30,000-pound reaction load of the antenna fairing mortar. Deflections up to 0.246 inch were measured on the center web. Inspection of the structure upon completion of the test revealed no failure due to the ultimate test loads.

An impact bag, ablation shield S/N-12, tension straps, and restraint cables were assembled to a boilerplate capsule and drop-tested on September 15, 1961. Test parameters were 30 feet per second vertically, 65 feet per second horizontally, and impact was zero degree. The capsule did not tumble at impact. A 2,350-pound maximum load occurred on the tension straps and a 4-inch elongation resulted. One forward strap, punctured by a shield stud, failed. Minor shield cracking was noted at approximately 12-inch radius for $\frac{1}{2}$ the circumference.

During a period between August 5, 1961 and October 12, 1961, a series of environmental tests were conducted on the explosive hatch. Individual pieces of the mild detonation fuse (MDF) cord, detonator caps, and RDX lead cups were subjected to simulated altitudes of 118 miles and 135 miles and subjected to 25,000-volt +1.2 to 2.0 milliampere static discharges. No inadvertent ignition occurred. The units were then assembled into igniter assemblies and fired by pulling the lanyard. Full-order ignition occurred. Additional MDF cord was subjected to varying exposure in hydrogen peroxide. One condition resulted in a low-order detonation without igniting the full length of 12 inches. Two repeats of the same condition failed to induce detonation. The MDF was reduced to puddles of lead in all of these tests. Three inert igniter assemblies were subjected to push tests with shear pin removed, with and without vacuum, and with and without "O" ring. Minimum push force was 2.63 pounds. The assembly with minimum push force was subjected to vibrations of 0.03g to 10g at frequencies from 5 to 2,000 cycles per second with no displacement of plunger noted. A loaded hatch assembly, subjected to saline solution soak, with vacuum, electrostatic shock and vibration, was degraded to the point of "no fire" due to salt concentration degrading the detonator caps. This hatch assembly was disassembled, reloaded, and subjected to a simulated launch, three orbits, and reentry temperature test conditions. Pressure altitude during the test was 240,000 feet. Upon removal from the test chamber, the hatch was subjected to a saline solution soak and repeated electrostatic discharges. No detonation occurred. The hatch was then fired by lanyard pull and normal operation occurred.

Rockets and pyrotechnics.- During this period the retrograde rocket, posigrade rocket, pylon jettison rocket and explosive separator were accepted as fully qualified. The whip antenna cartridge qualification testing is scheduled to be completed early in November 1961.

Landing system (onboard).- The complete landing system and all components are fully qualified. The landing system functioned as planned during the MA-4 flight.

Environmental Control System.- The current status of the ECS is as follows:

(a) A problem area has arisen in the MA-4/8A mission in which an excessive amount of oxygen was used during the flight. Postflight testing indicated that the malfunction occurred with the emergency rate valve. The emergency rate handle apparently vibrated out of its detent, thereby allowing the valve to crack open just enough to cause the emergency rate system to permit a high flow of oxygen into the suit circuit. The small amount of movement, however, did not trip the valve's internal microswitch which would have given a telemetry indication of emergency rate actuation. To correct this situation, a new emergency rate handle, containing a positive latching mechanism, has been designed and installed in capsule no. 9.

(b) The procedures for replacing the main CO_2 canister just prior to flight have been incorporated and deemed satisfactory.

(c) Additional changes to the basic system design, as reported in Status Report No. 11, are as follows:

(1) A clip-type keeper has been installed on the conical spring of the suit pressure regulator tilt valve. This keeper will prevent the conical spring from inadvertently jumping out of its detent.

(2) In an effort to alleviate the inherent high cabin air temperatures that have been experienced in previous flights, the following modifications have been incorporated on later capsules: ducting installed from the vicinity of the inverters (high heat source) to the inlet of the cabin fan, and cold plates (heat exchangers) mounted under the main inverters. The effects of these modifications will be reported in the next Status Report.

(3) All capsules to date have been flown with the oxygen bottles pressurized to 3,000 psig; however, the later capsules will be flown with the bottles pressurized to the specification value of 7,500 psig. The flight results, with the oxygen bottles pressurized to 7,500 psig, will be reported in the next Status Report.

(d) The results of the operation of the ECS during the Atlas Training Program IV at the Navy Aviation Medical Acceleration Laboratory (AMAL), Johnsville, Pennsylvania have been satisfactory. The operational time spent on the system by the Astronauts was 70 hours plus 30 additional hours required for system check-outs for a total of 100 hours. No malfunctions were noted during this time.

Pressure suit.- The current status of the pressure suit is as follows:

(a) The astronaut pressure suits have been modified to include glove-bearing disconnects for improved wrist mobility. Several prototype gloves have been received and evaluated under the glove development contract with the B. F. Goodrich Company.

(b) A program has been initiated to improve the suit communications system. Evaluation and qualification tests for improved microphones and pigtails are being made at McDonnell, Electro-Voice, and R. E. Darling Companies.

(c) The blood-pressure cuff, connecting hose, and suit fitting were developed and successfully employed with the blood-pressure-measuring system during the Astronaut Training Program at Johnsville, Pennsylvania.

(d) A satisfactory urine collection device has been developed and evaluated for immediate flight requirements.

(e) An emergency life vest for suit mounting has been developed and successfully tested in open-sea rescue operations. This vest will be packaged on the suit in a container approximately the size of a cigarette pack. This device was developed in-house.

Bioinstrumentation.- A blood-pressure-measuring instrument has been developed for use in the manned orbital flights. This instrument was designed through a joint program with McDonnell, AiResearch Manufacturing Division of the Garrett Corporation, and the NASA. The device was successfully evaluated during the MERCURY Centrifuge Program No. 5. Baseline data were obtained for all Astronauts under simulated orbital flight.

Attitude Control System.- In the Project Orbit (capsule no. 10) tests, three Automatic Stabilization and Control System (ASCS) rate gyros have failed after 75 to 85 minutes operation under decompressed conditions. Further tests have revealed the necessity for using higher-temperature grease and insulation varnish. The vendor is presently rebuilding gyros incorporating these improvements.

In the MA-4 flight test, the data showed that the horizon scanners gave erroneous outputs which could be associated with high-altitude clouds in the scanner field of view. The scanners fitted in the capsule for the MA-5 mission have had circuit modifications carried out which should alleviate the problem. The outputs of the scanner preamplifiers have also been instrumented to enable a more satisfactory postflight analysis of horizon scanner performance to be made.

Reaction Control System.- Special RCS tests have been conducted at Cape Canaveral on capsule no. 15 to gather as much performance data as possible on the RCS before the first manned orbital flight.

The RCS experienced a period of reduced performance during the MA-4 mission. The 1-pound yaw positive and the 1-pound roll negative thrusters did not appear to generate thrust. As a result, the control system went out of the orbital mode. An investigation has been initiated to determine the cause of this discrepancy but as yet no definite explanation has been obtained.

Pilot Support and Restraint System.- Two problems involving the support and restraint system have been encountered since the last Status Report: Astronaut Grissom reported tangling of the shoulder and chest straps that might impede rapid egress; and a period of vibration that could be disturbing and possibly hazardous to a person was measured during the launch of the first unmanned orbital (MA-4) mission.

As a result of the tangled straps in Astronaut Grissom's mission, it has been suggested that the chest strap be deleted, thus eliminating the entangling of chest and shoulder straps. The chest strap had been added previously, however, because the astronauts were more comfortable during tumble runs in the centrifuge simulating an emergency abort at the maximum impact pressure condition. During these runs, however, a head restraint system had been used. Thus, these experiments were not exactly similar to the presently proposed situation of no head restraint or chest strap. For this reason, additional tests were conducted during the MERCURY Centrifuge Program No. V. One subject endured tumble runs without head restraint or chest strap in the centrifuge and was successively exposed to 3g, 5g, and 7g forward-acting forces which became backward-acting (into the straps) forces during the tumble. He reported that immediately after the 7g run he would have been able to monitor gages and handle switches. Subsequent neck and shoulder muscle soreness, however, convinced him that the chest strap would be useful and he has recommended that it be used. However, opinion as to the need for the chest strap is divided among the Astronauts. Since a clearly defined need is not apparent, use of the strap will be made optional. To assist in rapid release of the restraint harness, a quick-release cable has been developed and proof-tested on the Johnsville centrifuge during the fourth training session. This quick-release mechanism permits the harness to be released by a single action. This release cable will be installed on the first manned flight capsule in further validation of the laboratory work.

A transient vibration of 10 cycles per second started a few seconds after launch, building up to a peak of 2g to 3g in the vicinity of the capsule and then decreasing until it was damped out at about 20 to 25 seconds after launch. GD/A, however, plans to eliminate this vibration in the same manner they used to alleviate the fuel-sloshing problem. Measurements on the MA-5 mission will confirm whether the GD/A solution is successful or not. In the meantime, the physiological effect of this vibration of 10 cycles per second will be determined. The U.S. Air Force Aeronautical Systems Division at Wright Field, Dayton, Ohio will do this work using Air Force subjects. This study is necessary because it is questionable whether the seated-tolerance vibration data can be used to evaluate the physiological effect of the MERCURY supine position.

Controls and displays.- As reported in Status Report No. 11, the Redstone ballistic flight experience revealed some minor discrepancies in instrument layout and lighting. Fixes for several of these problems were underway prior to the Redstone flights. The other discrepancies noted have been taken care of through minor modifications. Among the recent additions to the instrument panel which will be available on capsule no. 13 which is programed for the first manned orbital flight and which were not available on the Redstone capsules are the following:

(a) Pushbutton controls to start and stop the blood-pressure cuff inflation

(b) A toggle-switch control for turning on and off the VOX power

(c) A guarded-inlet-valve power switch with a normal and a bypass position

(d) A toggle switch for selecting O_2 flow from primary and secondary bottles

(e) A toggle switch to control the extra set of cabin lights

(f) A toggle switch to turn on and off the low-frequency telemetry transmitter

(g) A revised cabin pressure regulating control which permits adjustment of the cabin pressure

Communications (onboard).- The status of the onboard communications equipment is as follows:

Changes - The C-band phase shifter has been fully qualified except for the humidity test. This test subjected the unit to 100 percent humidity soak which raised the insertion loss $\frac{1}{2}$ decibel. This is not considered serious and has been waived for capsule no. 9. A new potted unit has now been developed and will be given the humidity test. If the results are satisfactory, the unit will be used on future capsules.

Problem areas - MSC conducted tests on the HF voice in conjunction with the MERCURY Network and the U.S. Navy. HF transmission from St. Louis, Missouri was received by several MERCURY stations and by naval installations in Canada, Maine and Africa. Considerable interference was encountered from several Air Force stations during the test. This was due to the fact that this frequency is shared with the Air Force and they are not required to vacate this frequency except on manned orbital missions. However, fair reception was reported by the aforementioned stations. It was concluded that the system is a good backup aid.

MA-4 - Radar tracking was reported as inconsistent. Poor track was attributed to operator inexperience, aggravated by antenna pattern nulls. Good track was obtained by the more experienced operators. Telemetry coverage throughout the flight was consistently better than expected and definitely adequate to support mission monitoring and control. Air-to-ground HF and UHF voice was loud and clear at all sites from MCC through Woomera except Zanzibar, which reported a weak but readable signal. Ground-to-air voice was reported as satisfactory. The command system functioned normally. All rescue aids performed satisfactorily except the ultra-SARAH beacon, the faulty operation of which was due to a bad battery.

Instrumentation and recording.-

Cameras - The instrument panel observer cameras and astronaut observer cameras have been modified such that each camera now has its own individual programer contained within the camera housing. The new programers provide the cameras with a selection of two speeds differentiated here by high and low speed. The high speed for both the instrument panel observer camera and the astronaut observer camera is six frames per second. The low speed for the instrument panel observer camera is one frame per 2 seconds, and the low speed for the astronaut observer camera is one frame per 12 seconds. In flight the cameras will be programed to switch from low to high or vice versa during specific intervals that demand higher or lower frame rates.

Commutators - There has been an excessively high failure rate on the General Devices $90 \times 1\frac{1}{4}$ high level PAM/PDM commutator-keyers. (See Status Report No. 10, p. 11.) For this reason the GDI commutators are being replaced with Applied Electronics Corporation (AEC) commutators. It has been indicated that the AEC units have a higher reliability on the basis of like units now in use in the field, at Cape Canaveral, and on other projects.

Telemetry transmitters - Although the telemetry reception was better than expected on the MA-4 mission, it has been decided to replace the Texas Instrument (TI) transmitters with Electro-Mechanical Research (EMR) transmitters. This decision was based on the fact that the EMR has a better design and a higher reliability. The TI transmitters that were used on the MA-4 flight were handpicked from the available supply at Cape Canaveral. EMR transmitters were used with success on the Big Joe and MA-1 flights and will be used on MERCURY-Scout 1 and all MERCURY flights starting with MA-5.

General - Basically the instrumentation remains the same since Status Report No. 11, except for those items mentioned above and some smaller modifications.

Power supplies.-

Batteries - There has been no significant change in battery status since Status Report No. 11.

Information is being received continuously on battery characteristics from capsule no. 10 simulated test missions at McDonnell.

Inverters - As a result of a completed study on a modified inverter which will operate safely at 212° F and have 40 percent less heat loss due to higher operating efficiency, Interelectronics Corporation proposes that the modified unit can be produced with a nominal increase in weight of 10 ounces and a width increase of 1 inch. One each of the modified 150 v-amp and 250 v-amp inverters are on order for evaluation purposes, and should arrive at McDonnell on or before November 1, 1961.

Boosters

Atlas performance.- Preliminary estimates of the Atlas performance in the MA-4 mission indicate that previous analytical calculations of performance are approximately correct.

Guidance.- In the MA-4 mission, the guidance system guided the vehicle to an acceptable orbit; however, the performance near sustainer engine cutoff (SECO) was marginal because of excessive noise in the data. U.S. Air Force Systems Command, Space Systems Division (SSD), and Aerospace Corporation are investigating the guidance performance in order to determine the cause and means for improving the performance in future flights.

<u>Atlas abort-sensing</u>.- Current status of the Atlas Abort-Sensing and Implementation System (ASIS) is as follows:

(a) A test relay assembly has been incorporated in the abort system to permit countdown testing of the ASIS at approximately T-4 minutes. This test provides added assurance that the ASIS is in a "go" condition prior to engine start.

(b) Reliability testing has proceeded as follows:

	Percent of completion of search for critical weakness	Percent of completion of Life Test
(1) Pressure switches	100	100
(2) 3-second timer	100	Not applicable
(3) Gyros*	Starting retest	Not applicable
(4) Control unit**	Starting retest	75

(c) The MERCURY-Atlas flight MA-5 will be the fourth closed-loop flight of the system. The system performed satisfactorily on MA-2, MA-3, and MA-4 flights.

*Testing was completed; however, the addition of a "spin monitoring circuit" for countdown monitoring made it necessary to begin reliability testing anew.

**Modification to unit made it necessary to retest two units.

Crew Training

<u>MERCURY Johnsville IV Centrifuge Training Program</u>.- The fourth training program conducted for the PROJECT MERCURY Astronauts was designed to provide specific training for the normal Atlas launches and reentries. Each Astronaut received three sessions of centrifuge training during the month of September. During the first two of these periods, the Astronaut received six abbreviated missions during each session. These abbreviated missions consisted of a launch, turnaround, immediate retrofire and reentry. Four of the six missions were done in a dynamic condition, and two in a static condition with the centrifuge stationary. During the dynamic runs, linear accelerations typical of the Atlas missions were experienced during the launch, retrofire, reentry and chute deployment phases of the mission. The centrifuge gondola was

depressurized to 5 pounds per square inch to simulate the capsule environment on some of these runs and the pressure suit was used, both in the soft and in the pressurized mode. The final session for each Astronaut on the centrifuge was a complete simulation of a three-orbit flight. This involved a simulated period of countdown, a dynamic launch acceleration profile, followed by $4\frac{1}{2}$ hours at 1g, and then a dynamic reentry, followed by a simulated waiting period on the surface of the water. During all sessions, communications with ground control stations were practiced.

Orbital flight preparation.- A preflight program has been drawn up for the orbital flights. This program involves the following elements:

(a) Participation in the capsule check-out program at the launch site. The Astronauts act as inside observers during these checks. This provides an opportunity to familiarize themselves with the specific flight hardware.

(b) Initial use of the Procedures Trainer involves the development and perfection of the flight activities program and of communications procedures. Once the flight activities have been perfected, the major system malfunctions are reviewed during specially planned mission simulations. A set of missions for this purpose has been developed.

(c) A program of training on the Air-Bearing Orbital Trainer has been developed to perfect the Astronaut's capability to use the control system and to minimize his fuel consumption while maneuvering under manual control.

(d) A review with the capsule engineers of the status of the systems aboard each flight spacecraft is planned.

(e) Additional training sessions at the Morehead Planetarium, Chapel Hill, North Carolina are planned for the purpose of reviewing the celestial sphere. In addition, star charts and other training material have been accumulated at the launch site for use of the Astronauts. Briefings on astronomical observations which the Astronaut can make and which may be of importance to astronomy are planned in the near future by members of the NASA Astronomy Subcommittee.

(f) To aid the Astronauts in weather observations, a set of briefings by Weather Bureau personnel is planned, during which TIROS pictures and other material accumulated to date by the Weather Bureau will be discussed.

(g) A refresher program in capsule egress training will be conducted during the preparation program.

(h) Facilities for refresher code training have been provided at the launch site.

(i) To familiarize the Astronaut with the terrain over which he will pass during the flight, a map training facility has been set up at the launch site.

(j) To familiarize the Astronauts with some of the unusual sensations and visual illusions which they may encounter as a result of angular accelerations and weightlessness, a short program making use of the facilities at the Navy School of Aviation Medicine, Pensacola, Florida, has been planned.

(k) A short program of familiarization will be conducted in the area of vibration, using levels recorded on previous MERCURY-Atlas flights.

To facilitate the many Astronaut preparation activities which will be centered at the launch site, a section of the Training Office has been established at the launch site.

Animal Program

The current status of the animal program is as follows:

Training.- Five primates are now available for the complex orbital psychomotor tests. They have been trained and tested on the centrifuge at the University of Southern California (USC) on $4\frac{1}{2}$-hour simulated three-orbit runs in which they were exposed to noise and vibration as well as the acceleration of boost and reentry. Performance was satisfactory in all phases.

Couches.- The revised flight couches with advanced psychomotor apparatus, pellet and water feeders have now been in operational use for sufficient time to establish reliable performance and eliminate minor problems.

Sensors.- The temperature, respiratory and EKG sensors are satisfactory. The USC blood-pressure equipment has been extensively tested and changes were made at McDonnell to meet transducers and galvanometer breakdown during vibration testing. It has now been proved flight-worthy. With the exception of the postlaunch period T+40 to 100 seconds when the capsule vibrations will probably obscure the galvanometer records, it is anticipated both transducer and oscillograph units will perform satisfactorily. Two such complete units have been delivered for the MA-5 mission.

Trailers.- The modified caging and training vans with the new air conditioners are working satisfactorily and provide considerably more space. The three vans used at USC for the centrifuge tests are with the other vans at Hangar S where the animal facility has been readied for the MA-5 animal flight.

QUALIFICATION PROGRAM

The qualification program for PROJECT MERCURY is so planned that as many hardware items as possible will be exposed to, and their operation proven, in these environments to which they will be subject in both normal and emergency conditions for orbital flights. The following sections discuss the ground-test portion of this qualification program. The flight-test program is discussed in a separate section of this report.

McDonnell Qualification Program

The testing status of most of the primary systems is listed in the discussion of each system in the section entitled "Major Systems."

Failure summary reports listing failures and corrective action are being submitted monthly.

The qualification and reliability test programs are essentially complete except for the following equipment:

(a) Blood-pressure measuring system

(b) Nine additional telemetry channels for continuous monitoring, and approximately three commutated parameters.

Systems Tests

The current component testing of the various MERCURY systems is as follows:

Transient voltage tests.- Voltage transients on the main bus arising from normal squib firing and squibs shorted after firing were determined from tests on capsules nos. 10 and 15 under simulated flight conditions. The transients were of sufficient magnitude and duration to affect electronic component operation such as the maximum-altitude sensor, velocity sensor, time-delay relays and instrumentation. Extensive tests were conducted in the abort mode for a range of expected voltage levels on the main bus with various combinations of shorted and normal squib firing to evaluate the effects on the maximum-altitude sensor. Satisfactory operation of the maximum-altitude sensor was obtained with 1-ohm fuses protecting the squib circuits in place of the normal low-resistance fuses. Further, the 1-ohm fuses, which attenuate the voltage transients, prevented improper operation of the time-delay relays including relay chatter. The velocity sensor was still susceptible to malfunction with the attenuated voltage transient. However, the requirement for this component has been deleted.

Internal heat balance.- Flight tests and tests from capsule no. 10 have demonstrated that a heat problem exists within the cabin and possibly in the suit circuit. The cabin heat exchanger does not meet the specification requirement of removing 1,000 Btu/hr with the present fan. Two factors which control the amount of heat removed by the heat exchanger are the mass flow of cabin air through the exchanger and the change in temperature across the exchanger, both of which are below specifications. The addition of ducting to direct hot air from the inverters to the heat exchanger increased the temperature differential across the heat exchanger. A larger fan with 2.5 times the mass flow capability of the small fan failed to appreciably increase the mass flow due to the high total head losses through the exchanger. A stabilized cabin temperature of 115° F has been reached for the above configuration for an 18-orbit mission with capsule no. 10.

The effect of cold-plate cooling on cabin temperature is planned to be tested in the near future on capsule no. 10.

Decompress operation.- Another area of concern is component operations under decompressed conditions. In capsule no. 10 tests, the rate gyros have failed after about 75 to 85 minutes of operation in a near vacuum. Measures have been taken to extend the failure time by improving the lubricant in the bearings. Also, changes in insulation on the motor windings to withstand higher temperatures and changes in motor power are being investigated.

Batteries.- A bench test was conducted on one 1,500-watt-hour battery to determine its life under specified discharge rates and the rate of temperature rise. Temperatures (measured on four sides of the battery case), current and voltage were monitored during the test. Battery temperature was controlled by applying external heat.

The test lasted for 4 hours and 50 minutes with a high current drain, between 13 and 15 amperes (normal about 7 to 10 amperes), during which time the voltage dropped from 26.6 to 18.6 volts. The temperature increased from 130° F to 225° F. At 4 hours and 30 minutes, an electrolyte leak was noted, and at 4 hours and 40 minutes the test was terminated when the voltage dropped from 21.3 to 18.6 volts indicating that all usable power had been dissipated. After the tests, the battery was recharged indicating no permanent damage from using the higher than normal current discharge rate.

During the normal simulated flight operation in capsule no. 10 test, the maximum battery temperature was 178° F with a temperature rise of 7° F to 15° F per hour.

Inverters.- One 150 v-amp inverter blew a fuse during the MA-4 flight. After capsule recovery, this inverter blew fuses when vibrated at low frequencies and above 2g at lower than specification temperatures. Eighteen additional inverters were vibrated at higher than specification values without any failures.

Rocket Sled Test

The program initiated to study the detailed capsule-booster clamp-ring separation was described in Status Report No. 11. The results of the investigation are presented in the following paragraphs.

The capsule-sled assembly was completed and ready for delivery by MATS to Naval Ordnance Test Site at China Lake, California on August 23, 1961. Considerable delay in anticipated delivery time was caused by a complete sled stress analysis, in lieu of proof testing, and incorporation of minor "beef-ups" to increase safety factors.

Sled propulsion included four Nike boosters with a thrust rating of 49,000 pounds fired in two stages of two each. Staging was incorporated to reduce the initial acceleration to acceptable levels. Sustainer propulsion used nine 7,800-pound 1.8-second burning rockets fired to maintain a longitudinal acceleration of about zero during the test period.

The first run on September 5, 1961 appeared to be completely successful until unfired pyrotechnics were found along the range. Instrumentation gapping indicators indicated gapping between the clamp-ring fairing components at a dynamic pressure of 1,025 pounds per square foot and a velocity of 530 feet per second. Motion pictures taken at approximately 1,000 frames per second substantiated the gapping measurement and showed that the deflection in the fairing increased until the clamp ring broke before the explosive bolts were fired. Conditions at time of failure were: dynamic pressure = 1,248 pounds per square foot, Mach number = 0.955, velocity = 1,100 feet per second, longitudinal acceleration = +1g.

The second run on September 9, 1961, which covered the original test conditions, was very successful. The fairings were modified to include a small aluminum tab to prevent differential movement of the overlapping fairings and an overhang of about 0.1 inch of the upper fairings. A three-bolt firing initiated by the sequencing system occurred with no preseparation gapping of the fairing. Test conditions achieved were: dynamic pressure = 1,208 pounds per square foot, Mach number = 0.943, velocity = 1,075 feet per second, and longitudinal acceleration = +0.18g.

Run no. 3 on September 14, 1961 was a single-bolt fire separation. Two springs were incorporated to effect a cleaner separation of the fairing than that obtained on previous runs. This run was completely successful, thereby eliminating the requirement for any further runs. Test conditions were: dynamic pressure = 1,220 pounds per square foot, Mach number = 0.95, velocity = 1,095 feet per second, and longitudinal acceleration = +0.27g.

The capsule and sled were returned to St. Louis, Missouri by truck. The shingles were inspected and showed no damage due to the buffeting observed in the motion pictures. The capsule and sled are presently stored at McDonnell.

OPERATIONS

The operations for PROJECT MERCURY include such items as tracking and instrumentation systems, preflight and launch operations, flight control utilizing the network, recovery of the capsule and flight safety. The following sections discuss the present status, plans and schedules for the MERCURY flight operations.

Tracking and Ground Instrumentation Systems

Acceptance tests on all tracking sites have been completed and all tracking systems are approved. The tests indicated that the systems perform as well or better than their design specifications.

Radar - Both C-band and S-band radars are operational. Efforts are being made to improve systems performance by increasing sensitivity of both systems. The Bermuda station had a new low-noise mixer fitted on the AN/FPS-16 with a resultant decrease in the noise level from 11 decibels to about 6 decibels. The Verlort had a parametric amplifier put in place of a traveling wave tube (TWT) with a resultant sensitivity improvement of approximately 6 decibels. Both of these modifications are now being evaluated and will probably be adopted for all radars of the MERCURY Network.

All AN/FPS-16 radar systems in the MERCURY Network presently have a 500-nautical-mile limitation, except those at Cape Canaveral and Bermuda, where the range limit is 1,000 nautical miles. Consideration is currently being given to extending the range of all MERCURY AN/FPS-16 radar systems to 8,400 nautical miles. All AN/FPS-16 radar systems are also equipped with an Instrumentation Radar Acquisition (IRACQ) system and an optimization and standardization program is now underway to bring all the IRACQ installations to a common standard.

Efforts are also being made to improve Verlort tracking accuracy by reducing effects of antenna wind loading. One experimental mesh-type dish has been purchased for Bermuda. It is planned that all Verlorts will eventually be so equipped.

Performance of both types of radar during the MA-4 tracking was very poor. The difficulty is attributed to poor capsule antenna patterns in one or two instances, as well as inadequate radar operator performance in other instances. Specialized training to establish operational radar acquisition and radar hand-over procedures has been conducted in preparation for the MS-1 and MA-5 flight programs.

The communication link allocated to continental stations on the MERCURY Network is highly overloaded and is inadequate to accommodate the radar hand-over traffic. During the MA-4 mission, the radar operators had little opportunity to share the line. Efforts are now being made to improve the situation by providing a separate radar line, and appointing a radar controller to regulate the traffic.

Active acquisition aids - All active acquisition aids performed very well and pointed the telemetry antennas to the MA-4 capsule with sufficient accuracy. However, the pointing data given to the tracking radars do not appear to be good enough. Efforts are now being made to correlate active acquisition aids pointing data with those obtained at the radars.

Telemetry -

(a) MA-4 performance - The telemetry performance was satisfactory during the MA-4 mission. No major equipment failures occurred in either the capsule or ground telemetry equipment. All stations had solid telemetry coverage from approximately horizon to horizon.

(b) Station modification - Based on MA-4 experience, some modifications are being incorporated in the telemetry display system. These modifications include adding eight additional display meters to the display consoles at Bermuda and six additional meters at all other remote sites. An additional Sanborn recorder, for the use of the Capsule System Monitor, is to be added to all remote sites. NASA Goddard Space Flight Center (GSFC) is attempting to have these modifications incorporated in time for the MA-6 mission.

GSFC is also investigating methods to increase the HF and UHF voice input level to the Ampex FR-114B recorder. There were some instances during the MA-4 mission in which these levels were too low to produce satisfactory recording.

The input circuitry to the 100-channel event recorder will be modified to increase the range of switching adjustment.

In order to increase the flexibility of the display systems, lines will be added from the decommutator patch board to the display consoles, and all meters will be connected to separate lines. Previously, certain meters on the Aeromedical Display and the Systems Display were connected in parallel to a single line from the decommutator.

GSFC is attempting to have the three aforementioned modifications incorporated in time for the MA-5 mission.

MERCURY-Scout Test

The purpose of the MERCURY-Scout test to place a small communications satellite in orbit had been discussed in some detail in Status Report No. 11. The following paragraphs will present the current status. During the prelaunch check-out of the payload, a problem appeared in regard to the telemetry transmitters. Since the telemeters were radiating in the rather poor environment of a hangar with the launcher in close proximity to the payload, it was not possible to establish the cause of the poor telemetry transmissions.

The Blue Scout was transported to the launch pad on July 25, 1961 and was erected, and launch preparations followed. Work also continued to improve the quality of the telemetry transmissions which continued to be poor after erection of the vehicle.

At this time, a decision was made by NASA Headquarters to subject the payload to a more stringent vibration qualification test than had been accomplished. At about the same time, it was decided that the telemetry problem was unresolvable and that a change in the type of transmitter was required.

The payload was removed from the booster, and on August 6, 1961 it was returned to Aeronutronics Division, Ford Motor Company, at Newport Beach, California, where it was repackaged to accommodate the new type of telemetry transmitter, and subjected to a new vibration and thermal-vacuum environmental test program. While the payload was being reworked, some changes were made to improve insertion reliability of the booster. Changes were made in the interface between the third and fourth stages, in the fourth-stage igniter, and in the control system wiring harness.

On September 20, 1961, the payload was returned to Cape Canaveral for assembly to the Blue Scout vehicle. The vehicle was transported to the pad on October 22, 1961 and was erected; it is scheduled to be launched the morning of October 31, 1961.[1]

Launch Operations

Capsule preparations.- During this reporting period, preparations for launch of capsules nos. 8A (MA-4), 9 (MA-5), 12 (MA-6), and 13 (MA-6) were conducted at the Hangar S facility and at the MERCURY-Atlas launch pad, as well as special RCS tests using capsule no. 15. Capsules currently in prelaunch work include nos. 9, 12, and 13. Delivery of capsules nos. 16, 18, and 19 to Cape Canaveral is expected during the next reporting period. Capsule no. 15 will be returned to McDonnell.

MS-1 payload preparations.- Preparations for the launch of the MS-1 payload were conducted at the Blue Scout hangar and pad facilities. Telemetry transmitter difficulties experienced during the preceding reporting period were corrected and evaluated at the SSD facility in California and at Cape Canaveral. Final launch preparations are currently in progress.

Coordination.- Range documentation, including preparation of Mission Directives and Operations Requirements documents, has been completed for the MA-4 mission and partially completed for the MA-5 mission. Documentation for the MA-6 mission is progressing.

Successful coordination was accomplished with Department of Defense (DOD) and other NASA agencies to implement the MA-4 and MS-1 launch and network operations.

The manned orbital procedures for the prelaunch and launch periods have been exercised during this reporting period and are described in more detail in the "Flight Operations" section of this report.

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[1] Editor's note: On November 1, 1961, MERCURY-Scout 1 was launched. The test was terminated, however, shortly after lift-off due to erratic booster oscillations which continued to increase in magnitude until the vehicle finally destroyed itself.

The management and operation of the MERCURY Network, under the new arrangement described in Status Report No. 11, were successful for the MA-4 mission.

Data coordination activities were effectively exercised for the MA-4 mission. The Data Acquisition Plan, described in Status Report No. 11, was implemented successfully during this mission.

Flight Operations

Control Centers and flight monitoring.- During this period, Flight Controllers manned all MERCURY stations for the MA-4 mission, which took place on September 13, 1961. This included the site at Kauai Island, Hawaii, although it is not normally expected to acquire on a single-orbit mission. This was done for training and familiarization purposes, both for Flight Controllers and the permanent staff at the site.

Also for familiarization purposes, two Aeromedical Monitors, instead of one, were assigned to some sites and extra Capsule Communicators were assigned in some cases. In one case (the command site at Muchea, Australia) an Astronaut was assigned as Capsule Communicator. Instructors on the Langley Remote-Site Simulator were present at the Texas and California sites as observers.

Preparation has continued for the MS-1 launch. A countdown has been prepared for the launch by MSC. The launch and mission will be controlled and monitored from the MERCURY Control Center. Plans have been made at each site to test acquisition procedures.

A briefing was carried out at Langley Air Force Base on October 23, 1961 for the MA-5 mission and Flight Controllers are presently preparing for on-site preflight simulations and for mission support.

Training of flight-control personnel.- Some training of flight-control personnel was accomplished during the MA-4 mission. This was accomplished by augmenting the regular remote-site teams with Flight Controllers who had not had the opportunity to visit a site. All Remote-Site Capsule Communicators, most of the Aeromedical Monitors and many of the Astronauts were able to observe the MA-4 mission at a remote site. Others participated at Cape Canaveral and Bermuda.

The MERCURY Control Center staff and several Remote-Site Flight Controllers took part in simulation exercises for the MA-6 mission at Cape Canaveral.

Remote-site teams participated in a training program for the MA-6 mission at Langley Air Force Base on the Remote-Site Simulator during the latter part of the period. Emphasis was placed on training of the Medical Monitors, with EKG traces being supplied on the Sanborn recorder to simulate various astronaut health problems. The Remote-Site Flight Controllers were briefed on recovery procedures, mission rules, and the Environmental Control System for the MA-6 mission. This program proved highly successful in that the Astronauts participated on the air/ground communications link during the simulated missions. Emphasis on this type of training is planned for the preparation of the first manned orbital flight.

Recovery Planning and Preparations

Recovery equipment and tests.-

RADARC drop buoys - The qualification tests have been completed and the buoys successfully met the requirements of a 30-hour lifetime and 70-nautical-mile range (10,000-foot search altitude) with International Telephone and Telegraph Corporation (ITT), Simmonds, Ultra and ARA-25 receivers. The buoys have been delivered to the contingency recovery forces so that two of the aircraft at each contingency staging location will each have two buoys.

Auxiliary flotation device - Development and procurement of these devices have been completed. Fifty devices were manufactured by the Pensacola Naval Air Station and have been delivered to the contingency recovery support forces. A final evaluation test was conducted in the Atlantic Ocean off Wallops Island, Virginia. A production version flotation device was affixed to capsule no. 5 and the configuration was allowed to float freely. After 70 hours of continuous flotation in seas ranging from smooth to 7-foot waves, the device was still providing flotation and stability as designed. Post-test inspection revealed no excessive wear.

Tool kits - Special tool kits for capsule entry and occupant removal are being provided for the contingency recovery forces in connection with the on-scene emergency assistance support phase. These kits are programed to be available for the MA-5 mission.

SOFAR tests - During the subject period, a planned test, consisting of dropping a series of 35 SOFAR bombs, established satisfactory location capability ranging from east of the mid-Atlantic ridge to the Canary Islands. The SOFAR system was also shown to be capable of locating a signal source detonated at any time during a 1-hour listening period.

Ship retrieval tests - On October 26 and 27, 1961, tests were conducted to establish ship retrieval procedures for a manned MERCURY spacecraft. Three Astronauts took part in these tests utilizing capsule no. 5 (MR-2). The tests were supported by U.S. Navy destroyers of the 931 and Dealey Class operating in the Chesapeake Bay. In general, the tests showed that no significant problems exist for ship retrievals of manned MERCURY spacecraft.

Capsule seaworthiness test - The seaworthiness characteristics of the MERCURY landing configuration were evaluated during the period of August 1 to 3, 1961. The tests were conducted using production capsule no. 5 (MR-2) incorporating minor modifications to the cable attachment fittings made as a result of the seaworthiness test reported in Status Report No. 11. The test was conducted in the Virginia Capes Operating Area and was supported by the U.S. Navy.

Sea condition during the test varied from a ground swell of 5 to 15 feet and wave heights of 2 to 10 feet. Winds varied in intensity from 6 to 20 knots.

Within $2\frac{1}{2}$ hours, all straps had failed and the skirt had separated from the heat shield. After $9\frac{1}{2}$ hours, two cables failed and two more failed after 11 hours. At this point, cable failure was retarded due to reduction in wind and sea state. The test was halted at 33 hours with a total of 10 cables having failed.

Capsule flotation attitude was not affected by skirt and strap failure, but list angle increased from 35° to 50° at the time of first cable failures. At the end of the test, the list angle was such that the recovery compartment was continuously in water. It is concluded that for moderately rough sea states, the cable life would be between 10 and 15 hours after landings. This lifetime would not be adequate for contingency recovery situations; however, it is planned to augment the capsule flotation life by use of the auxiliary flotation device.

Nighttime location and retrieval - During the night of August 12, 1961 a capsule location and retrieval exercise was conducted in the Atlantic Ocean between Bermuda and Norfolk, Virginia. The exercise was planned to provide information concerning nighttime recovery operations. A training capsule equipped with specification location aids was used with recovery operations in the planned landing and contingency landing areas. In addition, a RADARC drop buoy was exercised. The results of the exercise, although not as comprehensive as expected, indicate that capsule nighttime location and retrieval is feasible.

Recovery operations.- The MA-4 recovery forces consisted of surface ships and aircraft in the planned landing areas of the Atlantic Ocean;

and helicopter, amphibious vehicles and boats in the launch-site landing area. Recovery units supporting the Atlantic area were positioned to provide a maximum access time of 3 hours in the end-of-orbit landing area and 9 hours in the other areas of the Atlantic. Aircraft were deployed to support contingency recovery within the lifetime of the capsule electronic location aids at any point along the ground track. All forces were in position at lift-off. The mission proceeded basically as planned and the capsule landed about 80 nautical miles short of the nominal landing point in the end-of-orbit landing area. Search aircraft were able to home on the SARAH beacons after main parachute deployment. The reentry contrail was spotted from an aircraft in the landing area. Shortly thereafter the same aircraft spotted the capsule descending on the main parachute and observed the landing. The capsule landed about 30 nautical miles away from a destroyer positioned in the up-range end of the landing area. Approximately 1 hour and 22 minutes after landing, the destroyer had recovered the capsule, antenna section, and main parachute. The capsule and other components were found to be in excellent condition and were delivered to Bermuda where an aircraft was waiting to return them to Cape Canaveral.

Flight Safety

Factory rollout inspection of boosters.- The Air Force/Aerospace factory rollout inspection of Atlas Booster 93D, to be used on MERCURY mission MA-5, was held at GD/A during the week of October 1, 1961. The booster was accepted and shipped to AMR on October 9, 1961.

Prelaunch Flight Safety Reviews at AMR.- Flight Safety Review Board Meetings to review the flight-readiness of capsule no. 8A for the MA-4 mission were held on August 17, 1961 and September 11, 1961. The second meeting was made necessary by postponement of the original launch date after discovery of faulty transistors in Atlas programers and other electronic components. The MA-4 Mission Review Meetings were held on August 22, 1961 and September 11, 1961. The Air Force Atlas Booster Status Review and Board Meetings were held on August 24, 1961 and September 12, 1961.

The Mission Review Meeting for the first MERCURY-Scout test was held on October 30, 1961.

Reliability.- The status of the reliability and flight safety assessment program for the three-orbit mission is as follows:

Configuration	Crew capability	Responsibility	Completion date
July 1960	Use McDonnell judgment McDonnell Report No. 7929 (revised date 8/25/61)	Headquarters	November 14, 1961 (with final report)
April 1961	Man incapacitated	MSC	November 9, 1961 (with preliminary report)
April 1961	Use McDonnell judgment McDonnell Report No. 7929 (except crew equals unity during orbit)	MSC	November 16, 1961 (with preliminary report)
April 1961	Man equals unity during complete flight	MSC	November 23, 1961 (with preliminary report)

FLIGHT-TEST PROGRAM

The qualification program for proving the operation of all PROJECT MERCURY components includes a series of buildup flight tests which culminate in manned orbital flights. The following sections discuss this flight-test program in some detail. Twelve flights have been made with production MERCURY capsules and one flight with a recovered Little Joe capsule as follows:

(a) Pad abort flight on May 9, 1960, capsule no. 1 - successful. Discussed in Status Report No. 7.

(b) Suborbital Atlas flight (MA-1) on July 29, 1960, capsule no. 4 - unsuccessful. Discussed in Status Reports Nos. 7 and 8.

(c) LJ-5 flight on November 8, 1960, capsule no. 3 - unsuccessful. Discussed in Status Report No. 9.

(d) MR-1A flight on December 19, 1960, capsule no. 2 - successful. Discussed in Status Report No. 9.

(e) MR-2 flight on January 31, 1961, capsule no. 5 - successful. Discussed in Status Report No. 9.

(f) MA-2 flight on February 21, 1961, capsule no. 6 - successful. Discussed in Status Report No. 10.

(g) LJ-5A flight on March 18, 1961, capsule no. 14 - unsuccessful. Discussed in Status Report No. 10.

(h) MR-BD flight on March 24, 1961, capsule from LJ-1A - successful. Discussed in Status Report No. 10.

(i) MA-3 flight on April 25, 1961, capsule no. 8 - unsuccessful. Discussed in Status Report No. 10.

(j) LJ-5B flight on April 28, 1961, capsule no. 14A - successful. Discussed in Status Report No. 10.

(k) MR-3 flight on May 5, 1961, capsule no. 7 - successful. Discussed in Status Report No. 11.

(l) MR-4 flight on July 21, 1961, capsule no. 11 - successful. Discussed in Status Report No. 11.

(m) MA-4 flight on September 13, 1961, capsule no. 8A - successful. Discussed in section entitled "Atlas Flights."

Redstone Flights

The MERCURY-Redstone flight program was successfully completed on July 21, 1961 with the MR-4 mission which has been previously reported in Status Report No. 11. A summary of the complete MERCURY-Redstone program is presented in the following paragraphs.

MR-1 attempted launch.- The MR-1 attempted launch utilizing an unmanned capsule was made on November 21, 1960. The countdown on MR-1 had proceeded smoothly with no problems. At the firing signal, the booster engine started and accomplished lift-off, but in the process of lift-off, one of the two tail plugs that supply power to the booster pulled out sooner than the other. The plug still connected allowed a period of reverse current flow, or feedback, for approximately 40 milliseconds, which energized the booster-cutoff relay which in turn gave an engine cutoff signal to the booster. Upon the initiation of what appeared to the capsule to be a normal booster engine cutoff signal, the capsule sequencing system performed the normal functions of: (a) tower jettison, (b) arming the parachute barostat switches, the functions of which began immediately since the capsule was below normal actuation levels.

Normal sequence functions of firing of the capsule-adapter explosive bolts, the posigrade rockets and the retrorockets did not occur since these sequences were blocked by the presence of a 0.25g sensor which was subjected to 1g at all times.

The capsule was not damaged in any way. The booster, however, had risen approximately 4 inches and settled back, causing some local deformation and was, therefore, returned to MSFC.

<u>MR-1A flight</u>.- A new booster was shipped from MSFC for the MR-1A mission. MR-1A was launched on December 19, 1960, using the same capsule. The flight was successful. The capsule achieved an altitude of 116.6 nautical miles and a range of 207 nautical miles. The reentry deceleration was 12.4g, which was somewhat higher than planned because of slight booster overspeed. As a result of this flight, a design change was made in the booster velocity cutoff sensor which would give greater cutoff accuracy.

<u>MR-2 flight</u>.- The MR-2 flight was made on January 31, 1961. This was the second flight in the series. The occupant aboard was a chimpanzee.

The burning rate of the engine was greater than normal because of faulty engine thrust regulation. Propellant depletion was reached 0.4 second too soon and a capsule abort resulted.

The booster overthrust combined with escape motor firing produced a greater-than-normal exit velocity. This velocity and lack of retrorocket firing resulted in a range of 363 nautical miles, a maximum altitude of 136 nautical miles, a period of weightlessness of about $6\frac{1}{2}$ minutes with a maximum reentry deceleration of 14.6g.

The flight was successful, however, in that the primate occupant of the capsule withstood the flight with no ill effects, continuously performing his given tasks.

During this flight, two capsule malfunctions occurred. Upon landing, the heat shield made recontact with the capsule, puncturing the lower pressure bulkhead and later broke away from the capsule, allowing the capsule to lay over on its side. As a result of the punctures and laying over on its side, the capsule took on a large amount of water.

The second malfunction that occurred was the loss of cabin pressure. The air inlet valve opened during ascent at about 18,000 feet so that the cabin did not maintain pressure; however, the suit-circuit mode performed as designed providing a satisfactory environment for the chimpanzee.

MR-BD flight.- The MR-BD (booster-development) flight was made on March 24, 1961. This flight utilized a nonoperative research and development type capsule recovered from the early Little Joe program. It was made to investigate the corrections made to the booster as a result of the problems brought to light on the MR-2 flight. The flight was successful and showed that all previous problems had been corrected.

MR-3 flight.- The first MERCURY manned space flight was successfully completed on May 5, 1961, with Alan B. Shepard, Jr. as the pilot. All systems performed satisfactorily for the flight and all phases of the flight were highly successful. The capsule achieved an altitude of 101 nautical miles, a range of 263 nautical miles, and was in weightless flight for slightly over 5 minutes.

MR-4 flight.- The MR-4 flight was made on July 21, 1961, with Virgil I. Grissom as the pilot. The flight was successful. After landing, however, due to premature actuation of the side hatch, the capsule was lost, but the pilot was rescued after having spent a short period in the water. The capsule achieved an altitude of 103 nautical miles, with a range of 263 nautical miles, with a period of weightlessness of about 5 minutes.

The MR-4 flight was the final flight in the MERCURY-Redstone program.

It was considered that all test objectives had been achieved and additional flights would contribute little to the over-all MERCURY program.

Atlas Flights

MA-4 flight.- The unmanned MA-4 capsule was launched at approximately 9:04 a.m., e.s.t. on September 13, 1961. Prelaunch holds totaled 2 hours and 4 minutes. No major troubles with the capsule or booster occurred during the countdown.

Ignition, lift-off, and roll and pitch programing were satisfactory. Booster vibration, except for a 10-cycle-per-second vibration of unexpected severity early in the flight, was about the same as on previous flights. A capsule inverter failed about 52 seconds after lift-off, but switchover to the standby inverter was made automatically. Some anomalies in the capsule scanner outputs and ignore signals were detected prior to escape tower jettisoning. A malfunction occurred in the capsule oxygen supply system whereas oxygen was depleted at a high ratio. The booster engines were cut off 2 seconds earlier than nominal. Jettisoning of the booster engines and escape tower were normal.

The 20 seconds of booster programed pitch-down was accomplished and G.E.-Burroughs guidance steering was initiated as planned.

The sustainer engine and vernier engines were cut off 10 seconds earlier than nominal. The flight conditions at cutoff were acceptable, with differences from planned values as follows: velocity, -20 feet per second; flight-path angle, -0.11°; altitude, -0.2 nautical mile. The low velocity at cutoff was due to the G.E.-Burroughs guidance system being noisy near the time of sustainer cutoff. Despite the noise in the guidance system data, a satisfactory orbit was indicated by a "go" recommendation from the computing system. The perigee and apogee of the orbit were lower than planned by 1.1 nautical miles and 11.0 nautical miles, respectively.

Capsule separation and 5 seconds of rate damping were accomplished satisfactorily. The capsule motions during turnaround and stabilization were abnormal. The maneuver took about twice the normal time, but the capsule stabilized in the proper attitude and the control system reverted to orbit mode operation (low fuel usage) as programed.

During orbit, the capsule systems operated in a generally satisfactory manner with the exception that the high usage of oxygen continued and the control system exhibited anomalies. These control system anomalies consisted of intermittent spurious scanner outputs, a continuous ignore signal from the roll scanner during most of the dark side of the orbit, and reduced or no output from some thrusters during the latter part of the orbit.

The telemetry reception at the MERCURY Network stations was excellent, with horizon-to-horizon contact at all stations. The air/ground communications were satisfactory for the first half of the orbit, but the second playback tape in the capsule failed to start and therefore no air/ground voice transmissions were made during the second half of the orbit. Radar tracking, both C- and S-band, was satisfactory at some sites and poor or nonexistent at other sites.

Retrofire was initiated by the clock at the time set prior to launch at 01:28:59. The retrofire was normal as was the entire sequence of events during reentry and landing. The capsule landed in the primary landing area at 32°09' N. latitude and 61°53' W. longitude. The time of landing was 10:53 a.m., e.s.t. The capsule was sighted from an aircraft while on the main parachute. A destroyer picked up the capsule at 12:15 p.m., e.s.t., 3 hours and 11 minutes after launch, and 1 hour and 22 minutes after landing. Postflight inspection showed the capsule to be in good condition.

MA-5 flight.- The MA-5 flight is scheduled for the week of November 27, 1961. Capsule no. 9 will be used for the flight and will have a primate aboard to evaluate the performance of the ECS.

During the planned MA-5 mission, the capsule will make three orbits around the earth at altitudes ranging from 87 nautical miles (perigee) to 135 nautical miles (apogee). Retrofiring will be by capsule clock with ground command backup as the capsule approaches the West Coast of the United States on the third orbit. Reentry (0.05g) will occur approximately over Florida and the capsule will land approximately 700 nautical miles southeast of Cape Canaveral, Florida.

PUBLICATIONS

The following papers relative to PROJECT MERCURY have been published during the last 3 months:

1. Smith, Robert P., and Moseley, William C., Jr.: Static Longitudinal Stability Characteristics of Various Mercury Escape Configurations and of a Proposed Alternate Escape Configuration for Mach Numbers of 0.05 to 9.60. NASA TM X-494, 1961.

2. Weston, Kenneth C., and Swanson, Joanna E.: A Compilation of Wind-Tunnel Heat-Transfer Measurements on the Afterbody of the Project Mercury Capsule Reentry Configuration. NASA TM X-495, 1961.

3. Sammonds, Robert I., and Dickey, Robert R.: Effectiveness of Several Control Arrangements on a Mercury-Type Capsule. NASA TM X-579, 1961.

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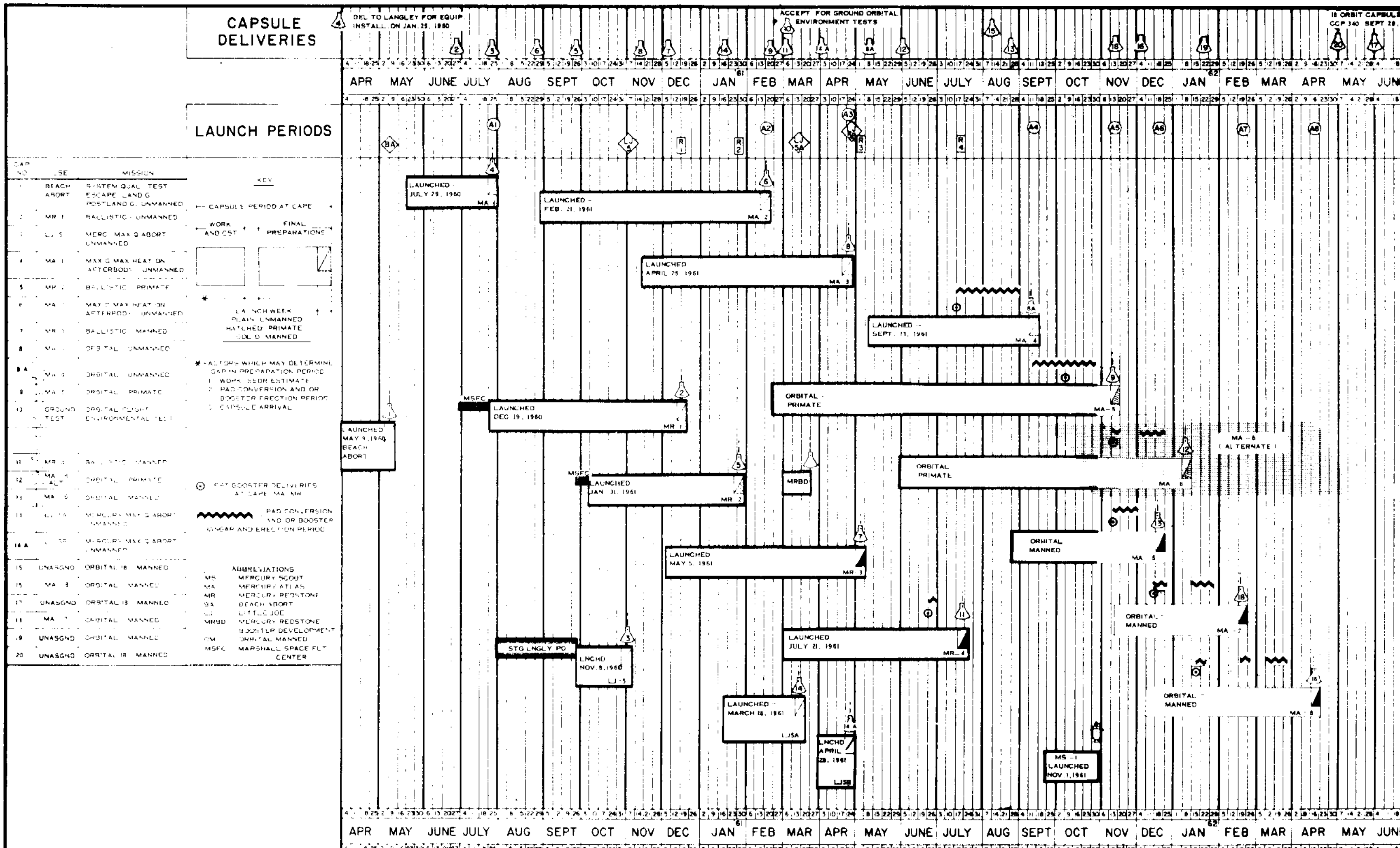

Figure 1.- **PROJECT MERCURY** master planning schedule status as of **11-1-61**

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